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AT&T

AT&T Bell Laboratories

subject: **AT&T OETC quarterly technical report for July-September 1992**

date: **October 9, 1992**

from: **J. L. Zilko**
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Enclosed please find copies of the Quarterly R & D Status and Technical Reports, including Financial Report, for DARPA Contract MDA972-92-C-0074 covering the period of July 1 through September 30, 1992.

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1. Overview of activities during July-September 1992

The activities of July-September 1992 have primarily revolved around planning the AT&T portion of the OETC program, interacting with IBM and GE concerning piecepart supply and system use of the transmitters, receivers, and connectors that AT&T is fabricating, and in transmitter, receiver, and connector design. Details of the various AT&T tasks follow:

1.1 Task A.1: VCSEL fabrication

A separately funded VCSEL process optimization experiment has been carried out during this last quarter in order gain design information for VCSEL fabrication for optical interconnection applications. This experiment has emphasized exploring process variables in order to achieve single lateral mode lasers that have low resistance. From these experiments (still in progress), we have fabricated single lateral mode lasers with > 1 mW power (cw, not heatsunk) and low threshold voltage (Vth = 2.2 V) at the expense of a somewhat wider beam divergence (~ 20°) than that of devices that we have previously fabricated.

Process parameters were also investigated to give optimum properties for interconnect applications by performing transmission experiments with IBM using single VCSEL's of several different designs. These experiments indicate that the use of multi-transverse mode devices (which are higher power and lower resistance) result in poor eye diagrams and, therefore, cannot be used for this application. Single mode (or almost single mode) lasers gave good eye diagrams. These measurements continue in order to help define a set of VCSEL specifications.

Milestone 1, Task A.2, Laser Chip Design Start has been fulfilled.

1.2 Task A.2: Transmitter packaging

The transmitter package is envisioned to consist of an optical subassembly (OSA) (shown schematically in figure 1) which contains a VCSEL piecepart accurately placed on a Si submount and a fiber connector part which contains a 32 fiber bundle accurately placed in V-grooves and which can be connected to an enhanced 32 fiber MAC (TM) fiber connector (developed in Task A.4 of this contract). The VCSEL and fiber connector parts are accurately aligned to each other to form the OSA. The OSA is then placed into a modified high speed, commercially available HIC which contains the laser driver array (obtained from GE), heat sinking, and electrical fanout to pins for attachment to the GE circuit board.

The design of the transmitter OSA was constrained by several issues. First, since the receiver chip from IBM uses a GaAs MSM detector, our VCSEL was constrained to wavelengths less than the bandgap wavelength of GaAs (< 860 nm). This, in turn, necessitated the use of top emitting VCSEL's since the GaAs substrate will be opaque at below bandgap wavelengths. If top emitting VCSEL's are to be bonded junction down, a cantilevered or via hole bonding configuration must be provided in order to have a clear optical path to the fiber. Unfortunately, simple thermal resistance calculations indicate that these junction down bonding configurations give only a marginally better thermal resistance than junction up bonding which is significantly more mechanically straightforward. The thermal resistance is due to the small area over which heat is dissipated in a VCSEL and the poor thermal conductivity of GaAs, AlAs, and AlGaAs. Thus, we decided to bond our VCSEL's junction up.

A second constraint was our desire to develop a low profile package for our VCSEL's. Because light is emitted normal to the plane of the chip, either the light needs to be turned 90° into a fiber or the electrical connections between the VCSEL and the driver array need to be turned 90°. Much of the work of the first quarter was spent in deciding between these two possibilities. Using a turning mirror to bend light into a fiber allows the use of more straightforward planar electrical connections with a natural low profile while coupling light directly into a fiber necessitates that electrical connections be bent 90°. Concern was expressed that bending the electrical connections might introduce excessive electrical loss and crosstalk due to the longer electrical connections that are required for this packaging configuration, especially given the high speeds (1 GHz) and tight pitch (140 μm) that are required for this program. In addition, a large chip (such as the IBM receiver chip which we are also packaging) would add considerable height to the package.

Thus, as shown in figure 1, it was decided to bond the VCSEL array light emitting side up and use a fiber mirror to turn the light into the fiber. This approach was chosen because of anticipated straightforward mechanical assembly, thermal design, and electrical design from this kind of "planar" package. The fiber mirror serves as both a turning mirror and a waveguide that is compatible (with some redesign) with the fabrication of a hermetic package. Although the optics using a turning mirror are somewhat difficult due to the non-round light beam impinging on the fiber core and a relatively large minimum distance between SEL and the center of the core (ie, the fiber radius = 62.5 μm), calculations were performed that indicate that good coupling (> 80%) is expected for reasonable alignment tolerances (~ 50 μm SEL-fiber separations, ~ 10 μm lateral placement tolerances) even with > 20° divergence angles.

Work has begun to define the hybrid package into which the OSA and the driver chips will be placed. The package that is envisioned is a high speed ceramic flat pack that is manufactured by AT&T and would be modified to accept the OSA. Particular attention is being paid to the thermal dissipation of the package since the laser is expected to dissipate ~ 1 W and the driver ~ 1.5 W. The electrical performance of the package and of various bonding schemes are also being carefully examined to characterize electrical loss and crosstalk at 1 GHz speeds.

In addition to stand-alone transmitter (and receiver) packages, we are willing to supply a limited number of transmitter (and receiver) OSA's to GE for direct mounting onto a multichip module using GE's HDI technology.

Milestone 1, Task A.2, Package Design (start) has been fulfilled.

1.3 Task A.3: Receiver packaging

Our receiver package design is planned to be similar to transmitter package that was described above in the Task A.2 section. This should ultimately allow reduced packaging development and manufacturing costs. Fiber coupling calculations have been performed that indicate a relatively small amount of beam spreading out of a 62.5 μm core fiber for fiber-detector gaps of ~ 100 μm or less. Due to focusing of the light by the fiber curvature, the beam divergence is especially small in the transverse direction. The calculations imply that good fiber-detector coupling should be achievable with a minimum of optical crosstalk between channels.

AT&T and IBM have had several detailed meetings to discuss the receiver chip and package. Several issues have come up that will need resolution within the next few weeks. Among them are backside wafer patterning that will facilitate accurate bonding placement, different metallurgies that are used among the various components (Al for the receiver, Au for the Si submount), IBM's suggestion that we make both single and two chip receivers, heat dissipation in package (since receiver could dissipate as much as 5 W), and bonding to the large number of I/O's that the receiver requires at very tight pitches (especially for the differential driver configuration).

Finally, the package for the receiver OSA is expected to be similar to the transmitter OSA package with an even greater necessity for good thermal dissipation due to the potential of 5 W power dissipation from the receiver chip and with the ability to handle many more I/O's than the transmitter requires.

Milestone 1,Task A.3, Package Design (Start), has been fulfilled.

1.4 Task A.4: Fiber connector

The fiber spacing was designated to be 140 μm. This value was chosen because the overall width of 32 fibers on 140 μm centers is approximately the same as the overall width of standard 18 fiber ribbon on 250 μm centers which allows fabrication of fiber ribbon using the same tooling as is used for fiber ribbon production. The only design changes that need to be made in order to fabricate the 32 fiber connector are obtaining fiber with 140 μm diameter and redesigning the Si piecepart.

The Si piecepart has been designed and quotes have been received for fiber and fiber cabling for 500 m of 32 fiber ribbon. Orders for the fiber and cabling have been written.

Milestone 1, Task A.4, Specify Fiber Spacing, has been fulfilled. Milestone 2, Task A.4, Acquire Fiber, has not been fulfilled. However, this is not expected to effect the overall Fiber Connector schedule.

1.5 Task A.5: Project Management

Considerable time and effort has been spent in planning this program and coordinating the efforts both within AT&T and between AT&T, IBM, and GE. Four intercompany meetings have been held to discuss OETC technical issues: two at AT&T, Murray Hill, New Jersey, one at IBM, Yorktown Heights, New York, and one at GE, Schenectady, New York.

2. *Anticipated activity for October-December 1992*

2.1 Task A.1: VCSEL fabrication

It is anticipated that the optimization experiment for the Version I VCSEL's will be completed, the OETC-specific mask set will be completed, and preliminary VCSEL specifications will be available.

2.2 Task A.2: Transmitter packaging

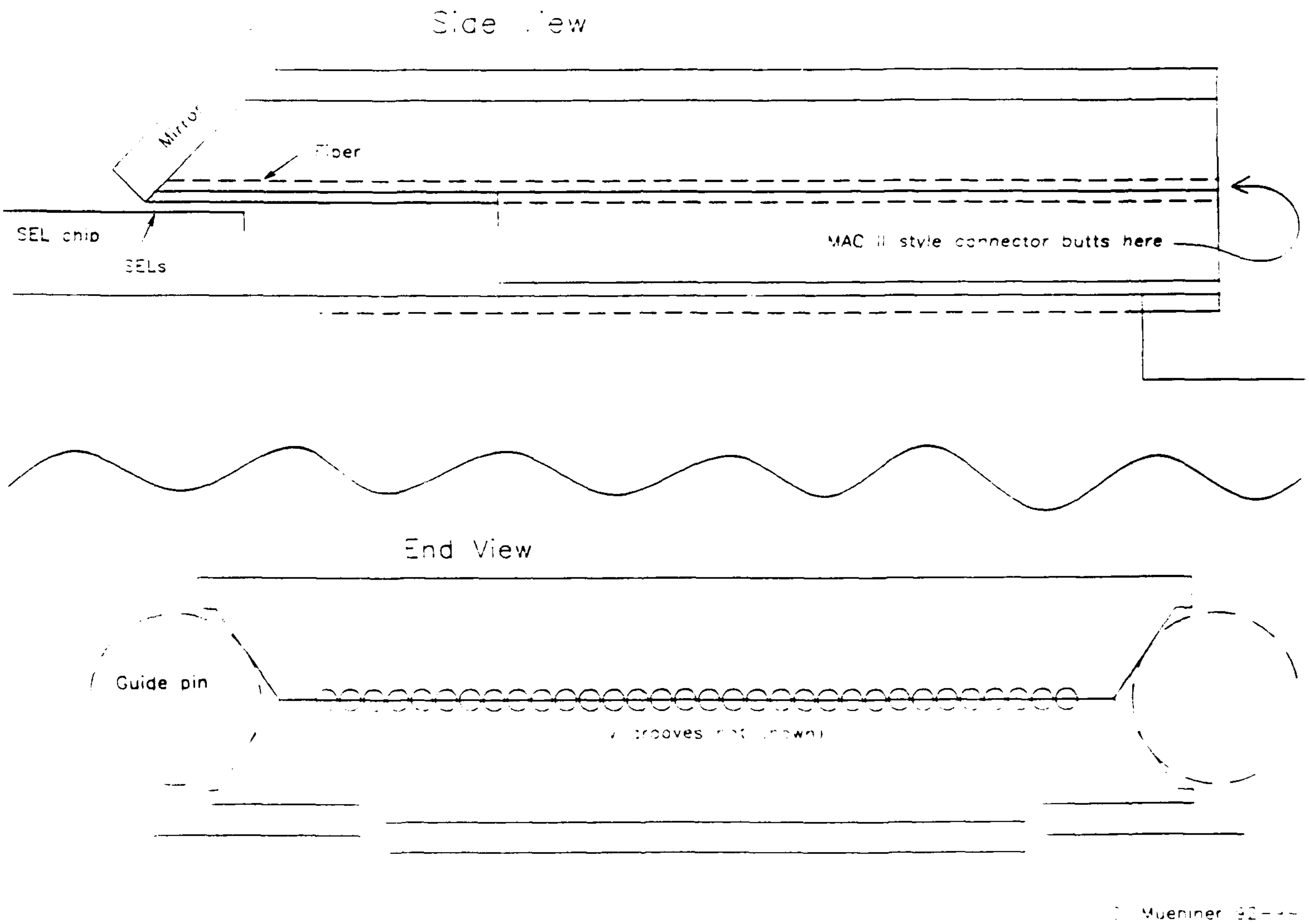
It is anticipated that the detailed design for the Si optical bench and the HIC will be complete, the Si optical bench mask design will be complete, and transmitter test set will be defined. In addition, we expect that preliminary transmitter specifications will be available.

2.3 Task A.3: Receiver package

It is anticipated that the detailed design for the Si optical bench and the HIC will be complete, the Si optical bench mask design will be complete, and information needed to design receiver masks will be transmitted to IBM.

2.4 Task A.4: Fiber connector

It is anticipated that the first connectorized 32 fiber cable will be available for this program.



Mirror
Fiber
SEL chip
SELs
MAC II style connector butts here
End View
Guide pin

Figure 1